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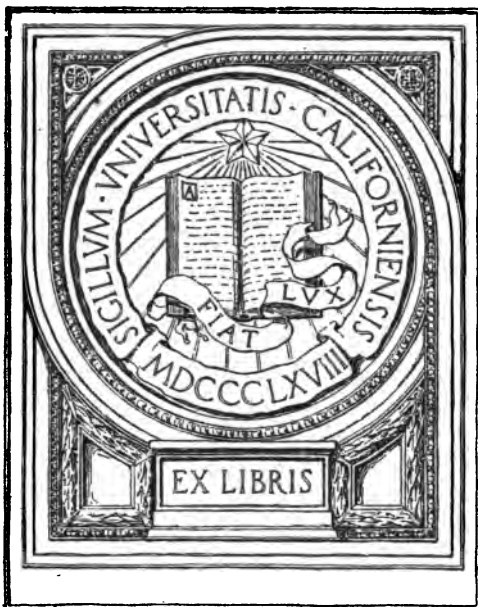
HISTORY
OF THE
CHEMICAL LABORATORY
OF THE
UNIVERSITY OF MICHIGAN
BY
EDWARD D. CAMPBELL

UC-NRLF



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THE NEW
LABORATORY



THE NEW LABORATORY SHOWING SOUTH AND EAST SIDES; WITH A REPRODUCTION OF THE
ORIGINAL LABORATORY UPON THE SAME SCALE

HISTORY
OF THE
CHEMICAL LABORATORY
OF THE
UNIVERSITY OF MICHIGAN
1856-1916

BY
EDWARD D. CAMPBELL
Professor of Chemistry and Director of the Chemical Laboratory
University of Michigan

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PREFACE.

The author has had in mind two principal objects in compiling the present work. The first is an attempt to give a condensed account of the development of chemistry, both pure and applied, at the University of Michigan, from the time this subject was first taught at the University down to the present. The second object is to preserve a permanent list of all those men who have constituted the instructing staff in the Chemical Laboratory, together with the years of their service therein, and a list of the scientific papers and other articles which they have published during the years of their official connection with the Laboratory.

The author wishes here to acknowledge fully his obligation to Dr. W. J. Hale for the great pains he has taken in collecting the titles of the papers and supervising the publication; to Dr. M. Gomberg for valuable advice concerning the classification and arrangement of the papers; to Dr. A. B. Stevens for much of the material used in preparing the illustrations; and to other members of the faculties for the assistance they have rendered in making the bibliography as complete as possible.

EDWARD D. CAMPBELL.

ANN ARBOR, APRIL, 1916.

LIST OF ILLUSTRATIONS FOR HISTORY OF THE CHEMICAL LABORATORY.

- FRONTISPIECE. The new Laboratory showing South and East sides; with a reproduction of the original Laboratory upon the same scale.
- PLATE I. The original Laboratory as built in 1856, showing the North and West sides.
- PLATE II. The Laboratory after the addition built in 1866, showing West and North sides.
- PLATE III. The Laboratory after the addition made in 1874, showing West and North sides.
- PLATE IV. The Laboratory after the addition made in 1880, showing West and North sides.
- PLATE V. The Laboratory after the addition made in 1888, showing West and North sides.
- PLATE VI. The old Laboratory as it appeared in 1907, showing West and South sides.
- PLATE VII. The new Laboratory built in 1909, showing West and North sides.

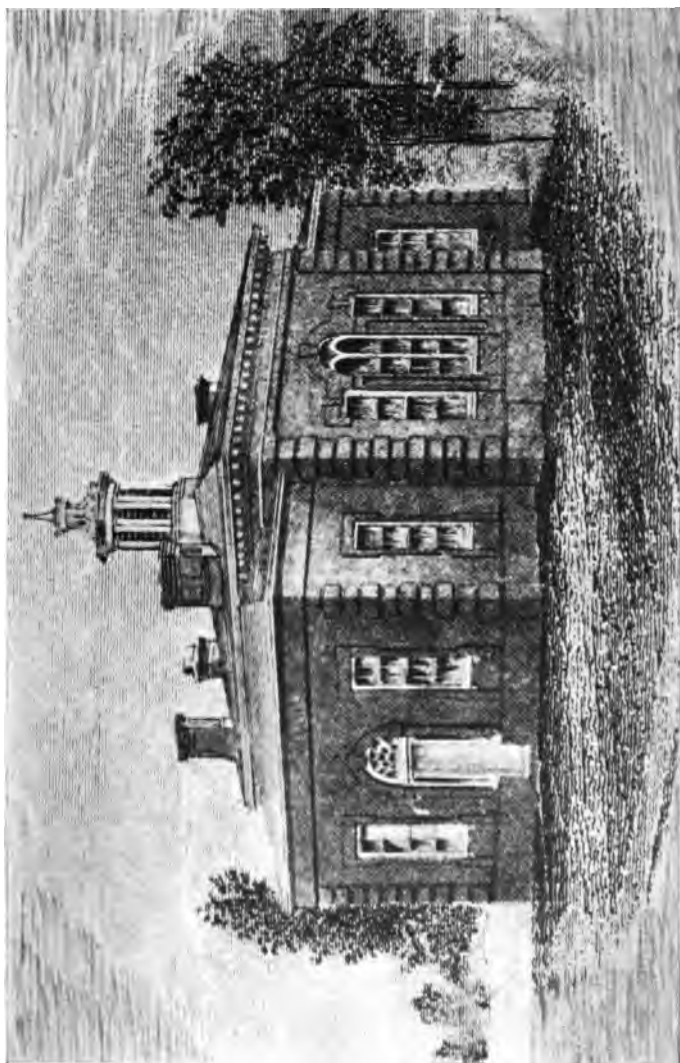
AN HISTORICAL OUTLINE OF THE DEVELOPMENT OF CHEMISTRY, PHARMACY AND CHEMICAL ENGINEERING, IN THE UNIVERSITY OF MICHIGAN.

Chemistry was the first of the experimental sciences to be taught by the laboratory method, and the development of the science at the University of Michigan has followed along lines similar to those which have been followed by many of the European as well as American Universities, although the lines of development at Michigan have been influenced by local conditions and the individuality of the men constituting the teaching staff.

Although Douglas Houghton was appointed Professor of Chemistry, Mineralogy, and Geology at the University of Michigan in 1839, chemistry was not taught at this University until 1844 when Silas H. Douglas was first appointed as assistant to the Professor of Chemistry. Instruction in chemistry dates from the year of Dr. Douglas' first appointment. At this time Liebig's Laboratory at Giessen, known as the first, had been established for sixteen years, and in 1842 Professor Silliman at Yale had begun to give laboratory instruction in chemistry. About this time also the private laboratory of Dr. Robert Hare in Philadelphia was a resort of special instruction in chemistry. When chemistry began to be taught in the University of Michigan the career of Berzelius was but just closing in Sweden. A. W. Hofmann was about going to London, by the efforts of the Prince Consort, to open a laboratory there. So little confidence had young Hofmann in his English venture that he only consented to go if the position of privat docent could be held open to him in Germany should he

wish to return. In 1851 Professor Josiah P. Cooke at Harvard began giving laboratory instruction, but Boylston Hall, long used in part as a chemical laboratory, was not completed until 1857.

When Henry P. Tappan came to this University to accept the Presidency in 1852 he brought with him a thorough appreciation of the value of the laboratory method of instruction in sciences. Laboratory courses in chemistry were organized in the University not long after Dr. Tappan's inauguration, and Dr. Douglas' persistent efforts to secure the construction of a chemical laboratory gained better foothold by the success of his little class which was carried on in the Medical Building and by the support of the new President. December 18, 1855, the report of President Tappan to the Board of Regents contained these words: "In respect to buildings the true principle is to build as little as possible. . . . It will be necessary, however, to erect a chemical laboratory for the analytical course. . . . Such a building will cost from two to three thousand dollars." A Detroit architect was employed, and on the eighth of May, 1856, the Regents voted that "Whereas a convenient building for the experiments and instruction in analytical chemistry is required, therefore, an appropriation of \$2,500 is hereby made for the erection of a building in conformity to the plans and specification of A. J. Jordan, architect," and Professor S. H. Douglas was made superintendent of construction. The several appropriations made for the building before it was occupied foot up to \$4,509.85, and July 1, 1856, the finance committee estimated that "the building and apparatus for erection and finishing would cost \$6,000." In October the President in his annual report set forth that the Laboratory "will unquestionably be unsurpassed by anything of the kind in our country."



I. THE ORIGINAL LABORATORY AS BUILT IN 1856; SHOWING THE NORTH AND WEST SIDES

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II. THE LABORATORY AFTER THE ADDITION MADE IN 1866; SHOWING WEST AND NORTH SIDES





IV. THE LABORATORY AFTER THE ADDITION MADE IN 1880; SHOWING WEST AND NORTH SIDES



III. THE LABORATORY AFTER THE ADDITION MADE IN 1874; SHOWING WEST AND NORTH SIDES



IV. THE LABORATORY AFTER THE ADDITION MADE IN 1886; SHOWING WEST AND NORTH SIDES



V. THE LABORATORY AFTER THE ADDITION MADE IN 1888; SHOWING WEST AND NORTH SIDES

Thus was completed the first chemical laboratory of a state university. In a one story building containing three rooms and equipped with twenty-six laboratory tables was carried on all the laboratory work in chemistry of the entire University. Academic as well as professional students received all of their laboratory training in chemistry in this one laboratory. This principle of having all the work in chemistry of whatever nature for the entire university centralized in one building was followed for a period of nearly fifty years, or until 1903, when the overcrowded condition of the Laboratory necessitated the removal of the laboratory work in physiological chemistry to the newly constructed Medical Building.

The growth of the work in chemistry due to an appreciation of the opportunity to carry on laboratory work as well as to the natural growth of the University, is shown by the rapid succession of additions to the Laboratory which this development necessitated. Enlargements to the building were made in the years 1861, 1866, 1868, 1874, 1880, 1888, and 1901. The number of laboratory tables increased from twenty-six, in the original building, to one hundred ninety in 1875, and to a total in 1901, after the last addition to the building, of 362, exclusive of a very limited number required for special work and those required for the use of the teaching staff. It was after the last addition to the old building that the continued growth of the work in other lines of chemistry necessitated the removal of the laboratory work in physiological chemistry in 1903.

Although the large amphitheatre in the Dental and that in the Medical Building were used for a number of years for lectures in chemistry and although the laboratory work in physiological chemistry was taken out of the old Chemical Laboratory, the continued growth of the work in other lines of chemistry soon showed that the construction of an entirely new building was an impera-

tive necessity. In the fall of 1907 architects were employed to draw up plans and specifications for a building which should meet the needs of the University for a number of years to come. Plans for a four story building, 270 feet in length by 150 feet in width, and having provision for about 950 laboratory tables in addition to a liberal provision for special rooms and members of the teaching staff, were approved the following spring by the Board of Regents and submitted to contractors for bids on the cost of construction. The estimates on the first set of plans were so high that it became necessary to reduce the size of the building and a new set of plans providing for a four story building 230 feet in length by 130 feet in width were approved, and contracts for its construction were authorized on September 24, 1908. These contracts, which did not include installation of equipment or apparatus, amounted to \$245,918.65. The total expenditure on the building with equipment has been to date about \$305,000. The present Chemistry and Pharmacy Building, which retains the essential features of design and arrangement of the original plans, is provided with 634 laboratory tables, in addition to an ample number of well equipped rooms for special work and for the use of members of the teaching staff.

During the college year 1908-1909, the last year in which all the chemical work was carried on in the old Laboratory, there were enrolled in the class work in chemistry, pharmacy and chemical engineering 2,599 students. Of these 20.8 per cent were registered in the College of Literature, Science and the Arts; 37.1 per cent in the College of Engineering; 12.6 per cent in the Medical School; 16.6 per cent in the College of Pharmacy; 1.9 per cent in the Homœopathic Medical School; 10.0 per cent in the College of Dental Surgery; and 1.0 per cent in the Graduate School. During this same year there were enrolled in the laboratory courses 1,271 students,

an average of 3.5 for each of the laboratory tables in the building. Of the students taking laboratory work 33.1 per cent were registered in the College of Literature, Science, and the Arts, 30.6 per cent in the College of Engineering, 6.5 per cent in the Medical School, 18.0 per cent in the College of Pharmacy, 1.3 per cent in the Homœopathic Medical School, 8.3 per cent in the College of Dental Surgery, and 2.2 per cent in the Graduate School.

Of the 3,497 students enrolled in class work in chemistry, pharmacy, and chemical engineering during the college year 1915-1916, 28.3 per cent were registered in the College of Literature, Science, and the Arts, 41.6 per cent in the College of Engineering, 0.3 per cent in the Medical School, 14.7 per cent in the College of Pharmacy, 0.2 per cent in the Homœopathic Medical School, 10.9 per cent in the College of Dental Surgery, and 4.0 per cent in the Graduate School. During this same year enrollment in laboratory courses showed 2,253 or an average of 3.6 for each of the 634 laboratory tables in the building. Of the students taking laboratory work 35.2 per cent were registered in the College of Literature, Science, and the Arts, 36.9 per cent in the College of Engineering, 0.4 per cent in the Medical School, 11.4 per cent in the College of Pharmacy, 0.2 per cent in the Homœopathic Medical School, 11.0 per cent in the College of Dental Surgery, and 4.9 per cent in the Graduate School.

The practical absence of students registered in the Medical Schools in the enrollments of 1915-1916 is due to the fact that between the time of these enrollments the entrance requirements for the Medical Schools were raised so as to include at least two years of college work before registration in them, during which time students are required to complete all the work in chemistry formerly taken after registration in the Medical Schools.

It is within the Chemical Laboratory that the College of Pharmacy was developed. Although courses in pharmacy were given in conjunction with courses in analytical chemistry as early as 1860, a regular curriculum was not drawn up until 1868. The degree of Pharmaceutical Chemist was first conferred in 1869, but the College was not organized as an independent department until 1876-1877. In addition to his position as Professor of Organic Chemistry, Dr. Albert B. Prescott was appointed Dean of the College of Pharmacy in 1876, which position he filled for over twenty-eight years. During Dr. Prescott's administration—and in no small part due to his efforts—the standards of pharmacy were very much raised, not only in Michigan but throughout the entire country. Dr. Prescott's keen appreciation and encouragement of research in other branches of chemistry than pharmacy went far toward the establishment of a spirit of research throughout the Laboratory. The design of the department, as stated at the time of its organization, was to "qualify its graduates to become practical pharmacists, general analysts, and commercial manufacturers, and to give the training of systematic work in exact science." The first requirement for admission was that of "a good knowledge of the English language as determined by a written examination," but the full preparation of the ordinary high school was soon made requisite. The degree was obtained by successful students at the expiration of two years. It was not long until graduate work and a Master's degree were announced, and in 1896-1897 the degree of Bachelor of Science in Pharmacy was added. The course for this degree was one of four years, its entrance requirements and first year's work being uniform with those for the academic degrees in science. In 1913 the curriculum leading to the degree of Pharmaceutical Chemist was lengthened so as to require three years for its completion.

the degree of Graduate in Pharmacy being given to those who had satisfactorily completed the former two year curriculum.

Before the establishment of the Michigan Agricultural College at Lansing some lectures on agricultural chemistry were given at the University; but as those responsible for the development of chemistry here felt that the field of agricultural chemistry properly belongs to the State Agricultural College, no efforts have been made to develop this subject at the University.

Among the first laboratory courses given in 1854, when the laboratory work was carried on in the Medical Building, was one in toxicological analysis. Work of this kind continued to be given, the material analyzed being such as would be of value to students of the Medical School. This work in physiological chemistry was largely developed in the Chemical Laboratory up to 1903, the instruction, however, being given mostly by members of the Medical Faculty so that this branch of chemistry has been more associated with the development of the Medical School than with that of the Chemical Laboratory. In 1888 the work in hygiene was transferred to the building constructed for the Laboratories of Hygiene and Physics, and fifteen years later, on the completion of the new Medical Building, the laboratory work in physiological chemistry was taken out of the Chemical Laboratory.

In the early years of the teaching of chemistry in the University the work was given entirely by lectures covering the principles of chemistry and its applications, and when laboratory work was introduced this consisted very largely of analytical methods and their applications. In 1846, Heinrich Will, at that time an assistant to Liebig, published an outline of chemical analysis in which he embodied the ideas on this subject as taught in Liebig's Laboratory. A few years after its translation into Eng-

lish, Will's "Outline of Chemical Analysis" was adopted in this Laboratory. In 1864 Dr. Douglas compiled a set of analytical tables which went through three editions, the last being published in 1868. These tables were then used in conjunction with Fresenius' "Manual of Qualitative Analysis" for several years. In 1874 the first edition of Douglas' and Prescott's "Qualitative Chemical Analysis" appeared, and thereafter served as the text book for teaching this subject. This text was revised in 1876 and again in 1880. In 1892 the work was rewritten and enlarged, appearing under the joint authorship of Prescott and Johnson. The fifth edition of this book further revised and enlarged appeared in 1901, and a sixth revised edition was published in 1908. This edition is still considered one of the best empirical manuals of qualitative analysis in the English language. Almost from the beginning of laboratory work in this University the value of a thorough course in qualitative analysis as a disciplinary training in the power of close observation and deduction has been appreciated by those in charge of the work, and this is perhaps the reason why more time has been devoted to this subject than is usually required. The disciplinary value of qualitative analysis was appreciated by no one more than by Professor Otis C. Johnson, who for more than thirty years was in charge of this subject.

In 1880 the Laboratory of General Chemistry was established. With this was developed, between 1895 and 1900, a laboratory of physical chemistry, with a force of instruction and an equipment demanded by the rapid growth of this branch of science. General and physical chemistry were provided for in the Chemical Building, with a separate organization, a provision not unlike that of the "Second Chemical Laboratory" of some German Universities. In 1904, however, on the resignation of the director of the laboratories of general

and physical chemistry these laboratories were united with the laboratories of organic, analytical and applied chemistry under a single administrative head; the College of Pharmacy, however, retaining an independent organization.

A distinct increase of activity in scientific research, particularly in the line of organic chemistry, was noticeable in the early nineties and the research spirit stimulated at this time has continued in its development down to the present. This stimulation of the spirit of research was due in large measure to the work of Dr. P. C. Freer, between the years of 1889 and 1904, in which year he resigned the Directorship of the Laboratory of General Chemistry.

With the rapid development of metallurgical industries, particularly that of iron and steel in the early seventies, there arose a demand for chemists who were trained in the analyses of metallurgical materials. and the University responded by developing courses in this work and carrying on research along this line. In 1885 there was organized in the College of Literature, Science, and the Arts, a curriculum leading to the degree of Bachelor of Science in Chemistry, which degree was conferred for the first time in 1886. In 1895 the College of Literature, Science, and the Arts decided to abolish all specified requirements for graduation and special degrees. As a result of this action the degree of Bachelor of Science in Chemistry was conferred for the last time in 1899. In 1898 a curriculum substantially that which had been required for the degree of B.S. in Chemistry, but with the addition of some work in engineering, was offered in the College of Engineering, the degree of B.S. in Chemical Engineering being conferred on completion of this work. This curriculum with some minor modifications is that still followed by students in the College of Engineering who wish to prepare themselves to enter

industries in which the services of the trained chemist can be of value.

In 1914 a curriculum providing for a thorough training in chemistry, but involving the substitution of some cultural studies and electives in other sciences for much of the engineering work, was again offered in the College of Literature, Science, and the Arts; the degree of B.S. in Chemistry to be conferred for satisfactory completion of the work.

On account of the peculiarly intimate relation existing between chemistry and the work of all the Colleges and Schools comprising the University, except that of the Law School, the Director of the Chemical Laboratory has always been responsible directly to the Board of Regents for the teaching of chemistry for the entire University and for the needs of the Chemical Laboratory.

In 1870 Dr. Silas H. Douglas was appointed first Director of the Chemical Laboratory, his full title being "Professor of Chemistry and Director of the Chemical Laboratory," which latter position he held until 1877, at which time his title was "Professor of Metallurgy and Chemical Technology and Director of the Chemical Laboratory." Although in 1880 the Laboratory of General Chemistry was separately organized from those of Analytical, Organic and Applied Chemistry, neither of the responsible heads of the Laboratories had the title of Director until 1884 when the title of Dr. A. B. Prescott was made "Director of the Chemical Laboratory and Professor of Organic and Applied Chemistry and Pharmacy." The following year this was changed to "Director of the Chemical Laboratory, Professor of Organic and Applied Chemistry and Pharmacy, and Dean of the School of Pharmacy." At the end of his administration in 1905 Dr. Prescott's title was "Director of the Chemical Laboratory, Professor of Organic Chemistry and Dean of the School of Pharmacy. In

1891 Dr. P. C. Freer, previously Professor of General Chemistry, was appointed Professor of General Chemistry and Director of the Laboratory of General Chemistry, which title he held until his resignation in 1904.

In 1905 the separation of the administrative control of the College of Pharmacy from that of the Department of Chemistry was indicated by the appointment of an independent dean for the College of Pharmacy; the title of the successor to Dr. Prescott was then made "Director of the Chemical Laboratory and Professor of Chemical Engineering and Analytical Chemistry." In 1914, upon his resignation of the Professorship of Chemical Engineering, the title of the Director was changed to "Professor of Chemistry and Director of the Chemical Laboratory."

Since the opening of the original Chemical Laboratory in this University there have appeared 746 articles published by members of the teaching staff during the years when they were connected with the Chemical Laboratory. Of these, 401 are original contributions to the science of chemistry, while 345 are other publications dealing with pure chemistry, pharmacy or chemical engineering. Of the original contributions about three-fourths have appeared during the last twenty-five years.

MEMBERS OF FACULTIES WHOSE WORK WAS CARRIED ON IN THE CHEMICAL LABORATORY OF THE UNIVERSITY OF MICHIGAN

WITH

YEAR OF APPOINTMENT TO RANK OF INSTRUCTOR OR ABOVE;
YEAR OF TERMINATION OF SERVICE IF TERMINATED;
AND TITLE HELD AT TERMINATION OF SERVICE
OR AT THE PRESENT TIME.

<i>Appointment Number</i>		<i>Year of Appoint- ment</i>	<i>Year of Termi- nation</i>
1	SILAS HAMILTON DOUGLAS, M.A., M.D., Professor of Metallurgy and Chemical Technology and Director of the Chemical Laboratory.	1844	1877
2	ALFRED DuBOIS, M.A., Assistant Professor of Chemistry.	1857	1867
3	ALBERT BENJAMIN PRESCOTT, M.D., LL.D., Director of the Chemical Laboratory, Professor of Organic Chemistry, and Dean of the School of Pharmacy.	1865	1905
4	PRESTON BENJAMIN ROSE, M.A., M.D., Assistant in Chemistry.	1866	1875
5	OTIS COE JOHNSON, Ph.C., A.M., Professor Emeritus of Chemistry.	1875	1912
6	JOHN WILLIAMS LANGLEY, S.B., M.D., Professor of General Chemistry and Metallurgy.	1875	1889
7	SAMUEL TOWNSEND DOUGLAS II, Ph.B., Ph.C., Assistant in Quantitative Analysis.	1875	1878
8	VICTOR CLARENCE VAUGHAN, Ph.D., M.D., Professor of Hygiene and Physiological Chemistry, Director of the Hygienic Laboratory, and Dean of the Department of Medicine and Surgery.	1876	1903

<i>Appointment Number</i>		<i>Year of Appoint- ment</i>	<i>Year of Termination</i>
9	BYRON WILLIAM CHEEVER, A.M., M.D., Acting Professor of Metallurgy.	1878	1888
10	DOUGLAS ARAD JOY, E.M., M.D., Assistant in General Chemistry.	1879	1881
11	THEODORE JOHN WRAPPELMEIER, Ph.C., A.B., Assistant Professor of Organic Chemistry and Pharmacy.	1881	1886
12	ALVISO BURDETT STEVENS, Ph.C., Ph.D., Professor of Pharmacy and Secretary of the College of Pharmacy.	1886	
13	FREDERICK GEORGE NOVY, Sc.D., M.D., Professor of Bacteriology.	1887	1903
14	DAVID HENRY BROWNE, Ph.B., Instructor in Quantitative Analysis.	1888	1889
15	PAUL CASPAR FREER, Ph.D., M.D., Professor of General Chemistry and Director of the Laboratory of General Chemistry.	1889	1904
16	CHARLES KING McGEE, A.B., Instructor in General Chemistry.	1889	1891
17	GEORGE WALTON WHYTE, B.S., Instructor in Metallurgy and Assaying.	1889	1890
18	FRANK CLEMES SMITH, B.S., Instructor in Quantitative Analysis.	1889	1890
19	EDWARD DEMILLE CAMPBELL, B.S., (CHEM.) Professor of Chemistry and Director of the Chemical Laboratory.	1890	
20	GEORGE OSWIN HIGLEY, M.S., Ph.D., Instructor in General Chemistry.	1891	1905
21	DAVID MARTIN LICHTY, Ph.D., Associate Professor of General Chemistry.	1891	
22	JULIUS OTTO SCHLOTTERBECK, Ph.C., Ph.D., Professor of Pharmacognosy and Botany, and Dean of the College of Pharmacy.	1892	
23	MOSES GOMBERG, Sc.D., Professor of Organic Chemistry.	1893	
24	WILLIAM FRANKLIN EDWARDS, B.S., Instructor in Organic Chemistry and Ac- countant in the Chemical Laboratory.	1893	1895

<i>Appointment Number</i>		<i>Year of Appoint- ment</i>	<i>Year of Termini- nation</i>
25	PERRY FOX TROWBRIDGE, PH.B., Instructor in Organic Chemistry and Ac- countant in the Chemical Laboratory.	1895	1901
26	PENOYER LEVI SHERMAN, PH.D., Instructor in General Chemistry.	1896	1899
27	DAVID LAKE DAVOL, PH.C., Instructor in Organic Chemistry.	1896	1897
28	ARTHUR LACHMAN, PH.D., Instructor in General Chemistry.	1896	1897
29	ALFRED HOLMES WHITE, A.B., B.S., Professor of Chemical Engineering.	1897	
30	SAMUEL LAWRENCE BIGELOW, PH.D., Professor of General and Physical Chem- istry.	1898	
31	ARCHIBALD CAMPBELL, PH.M., Instructor in Organic Chemistry and Ac- countant in the Chemical Laboratory.	1898	1899
32	GEORGE AUGUSTUS HULETT, PH.D. Assistant Professor in Physical Chemistry.	1899	1905
33	EUGENE CORNELIUS SULLIVAN, PH.D., Instructor in Analytical Chemistry.	1899	1903
34	FREDERICK LEVY DUNLAP, Sc.D., Assistant Professor of Analytical Chemistry.	1900	1907
35	ALPHONSO MORTON CLOVER, PH.D., Instructor in General Chemistry.	1901	1904
36	WILLIAM GABB SMEATON, A.B., Assistant Professor of General Chemistry.	1902	
37	WALTER HENRY BLOME, B.S., Acting Instructor in Pharmacy.	1903	1905
38	WILLIAM JAY HALE, PH.D., Associate Professor of General Chemistry.	1904	
29	RUBEN WILFRED BALCOM, PH.D., Instructor in Analytical Chemistry.	1905	1907
40	SAMUEL COLVILLE LIND, PH.D., Assistant Professor of General and Physical Chemistry.	1905	1915
41	HOBART HURD WILLARD, PH.D., Assistant Professor of Analytical Chemistry	1905	
42	KARL WILHELMI ZIMMERSCHIED, M.S., Instructor in Chemical Engineering.	1905	1911
43	LEE HOLT CONE, PH.D., Associate Professor of Organic Chemistry.	1906	

<i>Appointment Number</i>		<i>Year of Appoint- ment</i>	<i>Year of Termin- ation</i>
44	ROBERT JOHN CARNEY, A.B., Instructor in Analytical Chemistry.	1907	
45	HARRY NEWTON COLE, A.B., B.S., Instructor in Analytical Chemistry.	1907	
46	FERN L. SHANNON, PH.D., B.S. (PHAR.), Instructor in Pharmacy.	1909	1911
47	ELMER EDWIN WARE, B.S. (CH.E.), Professor of Chemical Engineering.	1909	
48	FLOYD EARL BARTELL, PH.D., Instructor in General and Physical Chemistry.	1910	
49	RICHARD CHACE TOLMAN, PH.D., Instructor in Physical Chemistry.	1910	1911
50	BERTRAND GRUNWALD, (DIPL.ENG.), Instructor in Chemical Engineering.	1911	1912
51	JAMES ELMER HARRIS, PH.D., Instructor in General and Physical Chem- istry.	1911	
52	WINFIELD SCOTT HUBBARD, PH.D., Instructor in Pharmacy and Acting Secretary of the School of Pharmacy.	1911	1914
53	ROY KENNETH McALPINE, A.B., Instructor in Analytical Chemistry.	1911	
54	ALBERT EASTON WHITE, A.B., Assistant Professor of Chemical Engineering.	1911	
55	WALTER LUCIUS BADGER, A.B., M.S., Assistant Professor of Chemical Engineering.	1912	
56	JOSEPH STANLEY LAIRD, PH.D., Instructor in Chemical Engineering.	1912	
57	JOHN DAVISON RUE, A.M., Assistant Professor of Chemical Engineering.	1913	
58	LOUIS THEODORE ANDEREGG, A.M., Acting Instructor in General Chemistry.	1913	1915
59	CLIFFORD CONKLIN GLOVER, Ph.C., M.S., Instructor in Pharmacy.	1914	
60	ALFRED LYNN FERGUSON, PH.D., Instructor in General and Physical Chemistry.	1915	
61	CLIFFORD CYRILL MELOCHE, PH.D., Instructor in Analytical Chemistry.	1915	

BIBLIOGRAPHY.

A double-column system has been introduced in the classification of the bibliographies of the members of the several departments. The names are given alphabetically.

Publications which present new data or new interpretations of earlier data are looked upon as original in their scope, and are grouped together on the left hand side of each page under the heading "Original Contributions." Publications which present merely analytical records and make no claims to originality in the methods of obtaining these records, even though the manner of presentation is new, are grouped together on the right hand side of each page under the heading "Other Publications."

In this latter category we may look for text books, addresses before scientific societies, popular articles and scientific discussions of various problems. Book-reviews properly fall under this head and accordingly may be found here as complete as it is possible to make them. In short the right hand column may be interpreted as showing the various activities of the members of the several departments outside of their researches proper. Each edition of a book must necessarily be given a separate entry, excepting wherein it is known to have received no further elaboration on the part of the author or authors; in such cases dates of re-printing are given under the titles at the last revision. Publications that lie entirely outside the realms of scientific work are not included; these, however, are but few.

In many cases, especially in earlier years, the same article is found to appear in several journals. Often-

times an article has been re-written and given another title. These articles of the same general context appear here under a single title (the first in point of date) and a number of citations to other journals in which they occur, either in the original or translated tongue, are merely added below. In this manner every publication cannot be numbered but only those which deal with new subjects or further elaborations of older subjects. As a matter of fact the right hand column contains so much oftentimes of minor or possibly local significance that it becomes difficult to classify by context. The result is that all or nearly all articles in this column are given each an individual entry, but without numbering. In the left hand column, however, the subject matter is clearly recognizable and articles of the same general context, unless they present further data, are classified together and given a single entry, as previously stated. These entries are numbered and stand correctly as an index of the original contributions to science. The two columns are presented in parallel chronological order.

Further, in order to avoid counting the same publication twice, when perchance it is the work of two members of the staff, it is given a number only under the work of its first-named author. If the first-named author is not of the staff at this University it naturally must be numbered under the work of the second-named author. Mention of a first-named author is made under the caption "In collaboration with" and placed in parentheses just before an entry for a second-named author; the names of second- or third-named authors collaborating with a first-named author are given of course in the entries for the latter, but only under the caption "with" and placed in parentheses directly after the title of article.

In order that the bibliography of each of the present members of the several departments may be made as



VI. THE OLD LABORATORY AS IT APPEARED IN 1907; SHOWING WEST AND SOUTH SIDES



VII. THE NEW LABORATORY BUILT IN 1909; SHOWING WEST AND NORTH SIDES

complete as possible, the work of each member, previous to his appointment at the University of Michigan, is given in italics at the beginning of his bibliography.

This bibliography includes all titles up to January 1, 1916. The abbreviations adopted for the publications of the American Chemical Society are followed wherever possible.

Walter L. Badger

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(In collaboration with W. F. Hillebrand.)

Errors in the Determination of Moisture in Coal.

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Floyd E. Bartell

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PUBLICATIONS

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Lawrence Bigelow.)

*The Size of the Pores in
Porcelain, and Osmotic Effects.*
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LAIN AND COPPER FERROCYAN-
IDE MEMBRANES.

J. Physic. Chem. 15, 659-674
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MEMBRANES.

J. Physic. Chem. 16, 318-
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Dissertation, University of
Michigan 1910.

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S. Lawrence Bigelow
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Trans. by B. B. Boltwood. New York: John Wiley & Sons 1899.

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30. NOTE ON THE OCCURRENCE OF COPPER, COBALT AND NICKEL IN AMERICAN PIG IRONS.
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31. THE APPLICATION OF DRY AIR BLAST TO THE MANUFACTURE OF IRON.
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INDEX

	PAGE
Analytical Chemistry	13
Anderegg, L. T.	22
Badger, W. L.	22, 27
Balcom, R. W.	21
Bartell, F. E.	22, 28
Bibliography:	
System of Classification	23-25
1856-1916	27-163
Bigelow, S. L.	21, 29-32
Blome, W. H.	21, 33
Browne, D. H.	20, 34
Campbell, A.	21, 34
Campbell, E. D.	20, 35-43
Carney, R. J.	22, 44
Cheever, B. W.	20, 45
Chemical Engineering	15
Clover, A. M.	21, 46
Cole, H. N.	22, 47
Cone, L. H.	21, 48-50
Davol, D. L.	21
Douglas, Samuel T.	19, 51
Douglas, Silas H.	7, 8, 14, 16, 19, 52-53
DuBois, A.	19
Dunlap, F. L.	21, 54-55
Edwards, W. F.	20, 56
Faculties, Members of, (1856-1916)	19-22
Ferguson, A. L.	22, 57
Freer, P. C.	15, 17, 20, 58-64
General Chemistry	14
Glover, C. C.	22
Gomberg, M.	3, 20, 65-73
Grunwald, B.	22
Hale, W. J.	3, 21, 74-78
Harris, J. E.	22, 79
Higley, G. O.	20, 80-81
Houghton, Douglas	7
Hubbard, W. S.	22, 82

Hulett, G. A.	21, 83-85
Hygiene	13
Johnson, O. C.	14, 19, 86-87
Joy, D. A.	20
Laboratory:	
First	8
Enlargements to First	9
New	10
Lachman, A.	21, 88
Laird, J. S.	22, 89
Langley, J. W.	19, 90
Lichty, D. M.	20, 91-92
Lind, S. C.	21, 93-95
McAlpine, R. K.	22
McGee, C. E.	20, 96
Meloche, C. C.	22, 97
Novy, F. G.	20, 98-100
Organic Chemistry	15
Pharmacy	12
Physical Chemistry	14
Physiological Chemistry	13
Prescott, A. B.	12, 14, 16, 19, 101-124
Registration:	
1908-1909	10
1915-1916	11
Rose, P. B.	19, 125
Rue, J. D.	22, 126
Schlotterbeck, J. O.	20, 127-132
Shannon, F. L.	22
Sherman, F. L.	21, 133
Smeaton, W. G.	21, 134-135
Smith, F. C.	20, 136
Stevens, A. B.	3, 20, 137-142
Sullivan, E. C.	21, 143
Tappan, Pres. H. P.	8
Tolman, R. C.	22, 144
Trowbridge, P. F.	21, 145
Vaughan, V. C.	19, 146-152
Ware, E. E.	22, 153
White, A. E.	22, 154
White, A. H.	21, 155-160
Whyte, G. W.	20
Willard, H. H.	21, 161
Wrampelmeier, T. J.	20, 162
Zimmerschied, K. W.	21, 163

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